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The Euro and Exchange Rate Stability

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TABLE OF CONTENTS

RÉSUMÉ

La création de l'euro sera un événement sans précédent dans l'histoire du système monétaire international. En effet, jamais un groupe de pays de l'importance des membres de l'Union Européenne ne s'est doté d'une seule et même monnaie. Quel sera l'impact de l'euro sur la stabilité des changes ? En particulier, une fois la transition vers l'Union Monétaire achevée, l'euro sera-t-il plus ou moins stable qu'un panier des monnaies européennes nationales ?

La formation de l'Union Monétaire Européenne va en effet modifier les déterminants de la volatilité des changes. Selon un premier argument, on risque de voir s'opérer un transfert de volatilité. Après la fixation des parités entre monnaie Européenne, l'instabilité des changes intra-européens se verrait transmise au taux de change de l'euro vis-à-vis des monnaies non-européennes. Selon un second argument, l'UEM constituera une grande économie, dont le degré d'ouverture sera très inférieur à celui de chaque pays membre. La Banque Centrale Européenne devrait, comme la Réserve Fédérale des Etats-Unis, attacher une moindre importance à la stabilité de son taux change.

Ce document de travail propose de traiter de l'impact de la formation de l'UEM sur le taux de change effectif réel de la zone euro à partir un modèle analytique simple.

L'économie mondiale est représentée à partir d'un modèle à trois pays que l'on nomme Allemagne, France et Etats-Unis. Les interdépendances entre ces économies passent par le marché des biens et par le marché des capitaux. Dans chaque économie nationale, le salaire nominal est rigide à court terme, mais il équilibre le marché du travail à long terme. La courbe d'offre est donc croissante à court terme, et verticale à long terme. La demande réagit positivement à une dépréciation du taux de change effectif réel (TCER) et négativement à une augmentation du taux d'intérêt réel. L'élasticité de la demande au TCER est proportionnelle au taux d'ouverture de l'économie qui est deux fois plus élevé dans chaque pays européen qu'aux Etats-Unis ou dans l'UEM. Les taux de change bilatéraux sont définis par des relations de parité non couverte des taux d'intérêt, et les taux de change effectifs sont définis proportionnellement à la structure du commerce, chaque pays échangeant autant avec chacun de ses deux partenaires.

Nous comparons deux régimes de change en Europe, changes flexibles et union monétaire, avec deux fonctions de perte alternatives pour les autorités monétaires. Dans une première version du modèle, chaque pays décide de sa politique monétaire de manière à minimiser une moyenne pondérée des écarts quadratiques de l'inflation et du TCER part rapport à des cibles choisies par les autorités. Le passage des changes flexibles à une situation d'union monétaire en Europe se traduit par une instabilité accrue du taux de change effectif réel du dollar. Le mécanisme en jeu tient à l'internalisation, par la banque centrale européenne (BCE), de l'externalité intra-européene de politique monétaire. En régime de flottement, lorsque la France et l'Allemagne subissent un choc de demande

positif symétrique, chaque partenaire relève son taux d'intérêt afin de contenir son inflation et de limiter ses pertes de compétitivité. Mais comme tous deux pratiquent la même politique, le taux de change intra-européen ne varie pas : le canal externe de transmission de la politique monétaire s'avère moins efficace *ex post* que chacun des partenaires ne le pense *ex ante*. En UEM, la BCE prend en compte l'efficacité réduite de la stabilisation du change et recherche davantage à satisfaire à son objectif interne, la stabilisation des prix. Il en résulte une volatilité accrue du TCER du dollar.

Le modèle permet également de comparer l'UEM et le SME. Dans ce dernier régime monétaire, la Bundesbank prend en compte le fait que son homologue française cherchera à maintenir la parité franc / D-Mark (Equilibre de Stackelberg en change fixe). Le taux de change du dollar réagit alors de la même façon dans les deux régimes de change aux chocs qui sont symétriques pour la France et l'Allemagne.

L'étude propose ensuite de confronter ces premier résultats à ceux obtenues avec deux autres choix de modélisations. On étudie d'abord le cas d'où les banques centrales ont des objectifs de prix à la consommation et d'écart à la production potentielle. Ici encore, le TCER du dollar réagit davantage aux chocs de demande symétriques en Europe lorsqu'on passe du flottement à l'UEM. Ce résultat tient toujours à l'efficacité relative de la politique monétaire au regard des deux objectifs. En régime de flottement, l'impact de la politique monétaire sur les prix à la consommation est surestimé dans chaque pays européen. En UEM, la BCE évalue correctement l'impact de la politique monétaire, ce qui la conduit à s'intéresser davantage à l'objectif de production : le taux d'intérêt européen réagit davantage aux chocs de demande. Dans le cas des chocs d'offre, les prix à la consommation et la production réagissent en sens inverse (un choc d'offre négatif a un impact inflationniste et récessif), et l'arbitrage entre les deux objectifs est modifié. Contrairement aux banques nationales européennes, la BCE ne sous-estime pas le coût de la lutte contre l'inflation en termes d'activité. Elle va donc modérer sa réponse à des chocs d'offre inflationnistes pour préserver son objectif de production, et le TCER américain est moins affecté.

On construit enfin une maquette dynamique à trois pays afin de simuler la réaction dynamique des taux de change à des chocs. Le TCER américain apparaît effectivement plus volatil en UEM qu'en change flexible, même si cette augmentation reste modérée pour des valeurs raisonnables des paramètres du modèle.

SUMMARY

The move to monetary union in Europe will represent a major change for the International Monetary System. Indeed, it will be the first time that large countries give up their national currencies to create a new, common money. This paper investigates the impact it will have on global exchange rate stability. More precisely, we examine whether the real exchange rate of the euro *vis-à-vis* third currencies will in the long run be more or less stable than the average real exchange rate of the corresponding basket of European currencies.

The reasons for investigating this issue are twofold. First, it is sometimes argued that EMU could give rise to a transfer of volatility, i.e. that the removal of exchange rate instability *within* Europe could result in a higher instability *between* Europe and the rest of the world. Second, it is also argued that the euro zone would be larger and mechanically less open than the constituting member countries, the European Central Bank could be less interested in achieving exchange rate stability. Thus, a kind of reciprocal benign neglect could develop between Europe and the US.

This paper introduces a simple analytical model to investigate the effect of European monetary union on the real effective exchange rate of the euro zone. .

The world economy is made up of three countries called France, Germany and the US, which are linked through goods and capital markets. For each domestic economy, the nominal wage is fixed in the short run and clears the labour market in the long run. The supply-curve is therefore positively sloped in the short run, while it is vertical in the long run. Demand reacts positively to a depreciation of the real effective exchange rate (REER) and negatively to an increase in the real interest rate. The impact of changes in the REER is proportional to the openness of the economy, which is twice as large in each European country as in the US. However, as France and Germany trade with each other, the euro zone is exactly as open as the US. Uncovered interest parity is supposed to hold.

We consider two policy regimes in Europe, a floating exchange rate regime and EMU, and two alternative loss functions that represent the policymakers' preferences. In a first scenario, each country sets its monetary policy as to minimise a weighted average of square deviation from target of its inflation rate and its REER. We show that moving from floating exchange rate, our benchmark, to EMU, leads to an increase in the volatility of the real effective exchange rate of the US dollar. This result is due to the fact that the European Central Bank (ECB) internalises the intra-European policy externality: when France and Germany are hit by a symmetric, positive demand shock, each European partner raises its interest rate in order to dampen inflation and to limit the loss of competitiveness. As both countries implement the same policy, the intra-European exchange rate does not vary: ex post, the exchange rate channel of monetary policy is thus less effective than expected ex ante. On the contrary, with EMU, the ECB knows that the exchange rate channel of monetary policy is less effective. She then puts more emphasis on its internal objective of price stability and the US REER turns out to be more volatile.

The model also allows EMU and the ERM to be compared. We assume that within the ERM, the Bundesbank knows that the Bank of France will maintain the FF stable against the DM (fixed exchange rate equilibrium with leadership). In the case of macroeconomic shocks which hit both European countries symmetrically, the volatility of the US REER is the same within EMU and the ERM.

In order to check for the robustness of the above results, we examine a second scenario where the central banks' loss function includes consumer price inflation and the output gap (rather than the REER). The same increase in the volatility of the US REER is obtained when moving to EMU in the case of symmetric demand shocks. Again, the underlying mechanism involves the effectiveness of monetary policy with respect to its two targets. Within the floating regime, decentralised monetary policy in each European country over-estimates its impact on consumer prices. This is corrected by the ECB who puts more emphasis on the output gap, leading to more volatile European interest rates. The case of symmetric supply shocks is however different. As consumer prices and the output gap move in opposite directions (i.e. a rise in inflation and a decline in output in the case of an adverse shock), coordination failures result in an excessively tight monetary policy in Europe. Under EMU, the ECB does not underestimate the cost of curbing inflation in terms of output. The European interest rate become less volatile and so is the US REER.

Lastly, we introduce dynamics with a small three-country dynamic model which allows dynamic simulations to be performed. We obtain again that the US REER is more sensitive to macroeconomic symmetric shocks within EMU than with the floating regime. Yet, quantitative analysis of this increase of volatility shows that it should remain moderate.

The Euro and Exchange Rate Stability

Agnès Bénassy-Quéré[1], Benoît Mojon[2] and Jean Pisani-Ferry[3]

INTRODUCTION

This paper deals with a single issue: will European Monetary Union (EMU) increase or reduce exchange rate volatility between European and non-European currencies? As the volatility of exchange rates between the dollar, the yen and the mark has been the focus of discussions and policy actions within the G7 since the early 1980s, this is an issue of some relevance in the discussion on the international implications of EMU.

In addressing this issue, we are concerned with the *permanent* impact of EMU, which should analytically be distinguished from the *transitory* effects that could arise from the introduction of the euro. In other words, we do not discuss here whether EMU could initially lead the euro to depreciate (because of a lack of credibility of the ECB, or of a diversification of private portfolios and transaction balances arising from the elimination of exchange rate variability and risk within the euro zone) or to appreciate (because the European currency will become an international one and its unified financial market will attract capital flows). These issues have been investigated in the literature (European Commission 1990, Gros and Thygessen 1992, Kenen 1995, Bénassy, Italianer and Pisani-Ferry 1994, Aglietta and Thygessen 1995), but without reaching firm conclusions, and they are the main focus of some of the papers assembled in this volume (Bergsten 1997, Alogoskoufis and Portes 1997). In order to put aside these transitory issues, we shall assume throughout this paper that the ECB has established its credibility and that whatever portfolio rebalancing which could arise from the introduction of the euro has already taken place. This leaves us with an analytically neat question, to which the literature has repeatedly alluded, but has only recently started to address explicitly (Cohen 1997, Giavazzi and Ghironi 1997, Martin 1997).

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It was suggested early on by some observers that the creation of EMU could increase exchange rate volatility vis-à-vis the dollar . There are two main grounds for such a claim, which respectively rest on a *stochastic stability* channel and on a *policy preference* channel:

(i) By removing exchange rate volatility *within* Europe, monetary union could result in a higher volatility *between* Europe and the rest of the world; the basic reasoning behind this intuition is that the locking of intra-European exchange rates will prevent them from fulfilling their buffer role, thereby leading to a transfer of shocks to the interest rate of the euro zone and ultimately to the euro-dollar exchange rate. Another, related motive for increased volatility could be that through aggregating several currencies, EMU could affect the stability of the Fundamental Equilibrium Exchange Rate of the euro in comparison to those of constituting currencies (Collignon, 1997). In other words, there could be a transfer of volatility from intra-European exchange rates to exchange rates between the euro and other currencies.

(ii) As the euro zone will be a comparatively larger and less open than individual member countries, it may collectively attach less weight to exchange rate stability as a policy target (Kenen, 1995). A kind of 'reciprocal benign neglect' could thus develop between the US and Europe, resulting in an increase in exchange rate volatility. Additional arguments stem from the provisions of the Maastricht Treaty, which emphasise the priority of controlling domestic inflation rather than external objectives.

These arguments clearly carry some weight. However, they fall short of being fully convincing. The validity of the volatility transfer argument is disputable: in principle, shocks affecting participant countries in an opposite way (e.g. a negative shock to Germany and a positive shock to France) should not trigger policy reactions from the ECB and therefore not impact on the exchange rate of the euro, and symmetric shocks should not affect the volatility of the euro exchange rate either, because the ECB would be able to react in order to offset any undesirable consequence they might have, exactly in the same way as national central banks in a floating exchange rate regime. Furthermore, the volatility transfer argument has been challenged by Flood and Rose (1995), who have shown argue that fixing exchange rates does not increase the instability of other macroeconomic variables. If fixing intra-European exchange rates basically removes a source of excessive volatility, there is no reason why this volatility should show up elsewhere in the macroeconomic system, and it could well be that the volatility of the dollar exchange rate would in the end be reduced. Stochastic stability considerations therefore do not lead to concluding unambiguously in favour of the increased volatility hypothesis.

The 'reciprocal benign neglect' argument can also be challenged. It is certainly true that because of its lesser openness, policymakers in the euro zone should attach less weight to the union's *effective* exchange rate than previously to those of the constituent countries. However, this does not imply that they should pay less attention to the exchange rate *vis-à-vis the US dollar* or the yen. At least, the argument needs to be refined. One reason for being less concerned with the value of the dollar could be that within the framework of the Exchange Rate Mechanism (ERM) of the European Monetary

System, intra-European exchange rates are sensitive to shocks to the dollar-DM rate (Henning, 1995)[4]. EMU would obviously remove this factor, but the extent to which this should affect the volatility of the dollar exchange rate depends on whether (under present monetary arrangements), the burden of stabilising intra-European exchange rates falls on the *Bundesbank* or on the central banks of other European countries. Furthermore, it was argued by the European Commission (1990) that a single European central bank could also find it easier to embark on exchange rate policy coordination with the Federal Reserve and the Bank of Japan, than several European central banks acting in a loosely coordinated way, if only because the reduction in the number of players would lower the informational cost of coordinating policies. There is therefore a clear case for examining how changes in European policy preferences could affect global exchange rate stability, but the issue has to be looked at in a precise way.

Although it has been the subject of casual remarks, the link between EMU and global exchange rate stability has until recently not been explored in a systematic fashion within the framework of a clearly specified model. Stochastic simulations with empirical macroeconometric models should provide some indications of the impact of EMU on the volatility of the dollar exchange rate, but since this was not the focus of their study, Masson and Symansky (1992) and Minford, Rastogi and Hughes Hallett (1992) do not give the corresponding results. Only the European Commission (1990) provides an evaluation of the effects of EMU on the bilateral exchange rates vis-à-vis the dollar, which suggest that its volatility should decrease in comparison to the free-float regime. However, the Commission's results have been criticised for relying on the assumption that most of the observed exchange rate volatility results from noise. Available stochastic simulations therefore fail to provide convincing evidence on the issue.

In this paper, we therefore begin by providing an analytical set-up for analysing the repercussions of supply, demand and speculative shocks in a world consisting of three countries, two of which decide to form a monetary union. We use it to develop a model in order to analyse the volatility of the real effective exchange rate (REER) of the US dollar under alternative European monetary regimes. We then use a similar set-up for numerical dynamic simulations.

The paper is organised as follows: Section 2 presents the analytical framework we use for our analytical assessment of the impact of EMU upon real exchange rate volatility. In Section 3, we analyse the impact of shocks in a floating exchange rate regime and in EMU as well as in the ERM. Section 4 is devoted to discussing the robustness of the results we get. In Section 5, we assess the magnitude of the static effects and present numerical simulations with a three-country dynamic model. Conclusions are drawn in Section 6.

[4] BIS (1996) provides evidence of the effects of fluctuations in the dollar-DM exchange rate on intra-European exchange rates.

1. EUROPEAN MONETARY REGIMES AND DOLLAR EXCHANGE RATE STABILITY : AN ANALYTICAL FRAMEWORK

In order to tackle the problem, we need a model that allows us to represent the formation of a monetary union among a subset of countries while remaining sufficiently simple to be solved analytically. This leads us to the realm of three-countries models, which are notoriously hard to keep tractable. We shall therefore make a number of simplifying assumptions.

The world economy is made up of three countries called U, G and F, which represent the US, Germany and France. The last two, the reunion of which forms the euro zone (which will be called Europe for the sake of simplicity), are supposed to be identical in all respects, but can be subject to asymmetric shocks. Furthermore, Europe is supposed to be identical in size and openness to the US. France exports a fraction η of its GDP to Germany and another η share to the US, and so does Germany. The US exports a fraction η of its GDP to Europe, equally divided between France and Germany. Along the baseline, all bilateral trade flows are therefore balanced, with each European country being twice as open as the US and (ignoring French-German trade) Europe as a whole being as open as the US. These assumptions are roughly consistent with empirical evidence. This kind of set-up is similar to those used by Cohen and Wyplosz (1989) and Canzoneri and Henderson (1991)

We shall consider three alternative exchange rate regimes between France and Germany: a floating exchange rate regime, in which each country separately sets its monetary policy; a monetary union regime, in which the European Central Bank (ECB) sets the common monetary policy for the two European countries; and an asymmetric system representing the ERM of the European Monetary System, in which the German central bank sets monetary policy while France keeps a fixed FF/DM nominal exchange rate[5]. Europe is always assumed to be in a floating exchange rate regime vis-à-vis the US. For countries in a floating exchange rate regime, no coordination is envisaged, i.e. the only outcome is a Nash equilibrium. In other words, we only envisage coordination within the framework of fixed exchange rate regimes.

The model for each economy is a standard open economy model with short run nominal rigidity adapted from Blanchard and Fischer (1989, Chapter 10)[6]. It has a short run, in which nominal wages are fixed, and a long run, in which they are flexible. Before exogenous shocks occur, full employment is assumed to hold, because wages are set at a level consistent with expected labour market equilibrium. After a shock occurs, there is no immediate wage renegotiation, therefore the short run supply curve has a positive slope. Unanticipated shocks may initially give rise to unemployment, but monetary policy is able to react to shocks and attempts to minimise a macroeconomic loss function. In the long run, real wages clear the labour market and the supply curve is vertical. Each country is specialised in the production of one good, which is an imperfect substitute to the production of the other two. Aggregate demand depends on the real exchange rate and the

[5] Realignments and fluctuation bands are ignored.

[6] Canzoneri and Henderson (1991) use a similar model to study policy coordination in the world economy.

real interest rate, so that goods markets are linked through relative price effects (quantity linkages are ignored for the sake of simplicity). Capital is perfectly mobile between countries, and uncovered interest rate parity holds.

The model is presented in Appendix 1. It is made tractable through an Aoki transformation which consists in defining « sum » variables which refer to European averages (with E subscripts) and « difference » variables which capture asymmetries between France and Germany (D subscribts). Finally, U subscripts refer to US variables.

It is assumed that monetary policy aims at minimising a macroeconomic loss function L (X), where X represents a set of macroeconomic variables. Obviously, the loss function depends in turn on the exchange rate regime. In what follows, we shall alternatively consider separate loss functions for France and Germany, and European loss functions representing the behaviour of the European central bank. Then, the robustness of the results will be discussed according to the choice of the variables to be included in the loss functions.

Long term equilibrium

Appendix 2 gives the long term solution of the model, assuming that shocks may have a permanent component. Except when the nominal exchange rate is fixed (ERM regime), the price flexibility insures that inflation does not have any real effect. Thus, the only possible aim of monetary policy in the long run is to minimise inflation, and the long-term solution does not depend on the exchange rate regime nor on the choice of a particular loss function. It is easily shown that the world real interest rate (which equals the nominal interest rate in this stationary equilibrium) is affected by symmetric worldwide shocks, while shocks affecting Europe and the US asymmetrically impact on the real exchange rate of the dollar and shocks affecting France and Germany asymmetrically impact on the real FF/DM exchange rate.

Short term equilibrium

The short term equilibrium is determined by setting nominal wages to zero. This nominal rigidity leads to a positively sloped short run supply curve:

(1) $$y_i = \frac{1-\alpha}{\alpha} p_i - \frac{1}{\alpha} u_i$$ 0 < a < 1 i=E,D,U

where y stands for output, p the price level and u for a negative productivity shock. Goods market equilibrium implies that supply equals demand, i.e.:

(2) $$y_i = \theta \omega_i q_i - \delta r_i + v_i$$ q, d > 0 i=E,D,U

with q being the real exchange rate, w the openness ratio (identical in France and Germany, $\omega_F = \omega_G = 2\eta$, while in the US, $\omega_U = \eta$), r the real interest rate and n a positive demand shock.

Combining equations (1) and (2) gives prices as functions of real exchange rates, real interest rates and shocks:

(3) $$p_i = \frac{1}{1-\alpha}\left(\alpha\theta\omega_i q_i - \alpha\delta r_i + \Gamma_i\right) \qquad \text{i=E,D,U}$$

with $\Gamma_i = u_i + \alpha v_i$

Consumer prices are easily derived:

(4) $$z_i = p_i + \omega_i q_i \qquad \text{i=E,D,U}$$

Equations (1) to (4) describe the functioning of each economy. Equations (5) and (6) represent the interactions through goods and capital markets. Goods market interaction results from changes in the real effective exchange rates:

(5) $$\begin{cases} q_E = \frac{1}{2}\left(s_E + p_U - p_E\right) \\ q_D = \frac{3}{2}\left(s_D - p_D\right) \\ q_U = -s_E - P_U + p_E = -2q_E \end{cases}$$

It is important to realise that due to the Aoki transformation, q_E is the average real effective exchange rate of France and Germany, which is not identical to the real effective exchange rate of Europe. The latter is simply the opposite of the exchange rate of the dollar (q_U = - 2 q_E). In a similar way, q_D is not the bilateral real exchange rate between France and Germany (which equals 2(s_D - p_D)), but half the difference of their effective real exchange rates. This is why a 3/2 factor intervenes in the equation for q_D [7].

The international asset market equilibrium is described by two real interest rate parity conditions that stem from the uncovered interest parity condition:

(6) $$\begin{cases} r_U = r_E + (q_U^{LT} - q_U) - \varepsilon_E \\ r_D = \frac{2}{3}(q_D^{LT} - q_D) + \varepsilon_D \end{cases}$$

ε_E and ε_D are transitory speculative shocks to the exchange rate equation, which can be seen as representing time-varying risk premia. We introduce these shocks because

[7] An example may help to clarify the reason for this factor. Suppose French price rises by 1 percentage point. The French real effective exchange rate appreciates by 1%, while the German one depreciates by 0.5%. Thus, the half-difference q_D decreases by 0.75%, while the half-difference of prices, p_D, increases by 0.5%. Hence, the 3/2 factor.

we want to represent the effect of speculative shocks which are correlated across currencies.

The model is closed with the three first-order conditions derived from the minimisation of the loss function. We now have to choose a loss function.

Central bank behaviour

As we intend to determine whether European monetary union is likely to affect the stability of the exchange rate vis-à-vis the dollar, a straightforward approach is to include explicitly the real exchange rate in the central bank's loss function. This kind of representation is able to capture recent (and possibly future) policy dilemmas facing the central bank when significant swings in the external value of the currency occur. Article 109 of the Maastricht Treaty explicitly envisages such dilemmas, as it states that the Council may formulate "general orientations" for the exchange rate policy of the euro zone vis-à-vis other currencies (implicitly the dollar and the yen), but that these orientations « shall be without prejudice to the primary objective of the ESCB to maintain price stability ».

This approach can also be considered a reduced form representation of the traditional trade-off between domestic objectives and the achievement of external equilibrium, under the assumption that the current account essentially depends on the real exchange rate. It was for example used by Persson and Tabellini (1996). But we consider more relevant in the present context to take the real exchange rate as an objective in its own right than more traditional ways of including an external variable among the policymakers' main objectives, like the inclusion of a current account target in the objective function.

Let therefore the loss function be:

(7) $$L_i = \frac{1}{2}(p_i^2 + \beta_i q_i^2) \quad i = G, F, U$$

where β is a coefficient that measures the relative weight of the real exchange rate objective as compared to the price objective[8]. We shall consider other loss functions in Section 4. What we need to do here is to determine the weight of this objective for the European central bank, i.e. to calculate β_E from β_F and β_A.

A natural way to proceed is to take as the European loss function a simple average of those of France and Germany[9]:

[8] The price variable in the loss function is the producer price. Using the consumer price instead does not qualitatively affect the results. The loss function is normalised so that the targets are set to zero.

[9] Masson and Symansky (1992) challenge this approach. They claim that as monetary policy in the euro zone will be based on aggregate variables, the monetary union's loss function should be directly expressed in terms of aggregate variables. However, this distinction is only relevant if the loss function is used for

(8) $$L_E = \frac{L_F + L_G}{2}$$

French and German prices and real exchange rates can be expressed as functions of the 'sum' and 'difference' variables using the property that $x_F = x_E + x_D$ and $x_G = x_E - x_D$. Assuming that $\beta_G = \beta_F = \beta$ and rearranging the expression, we obtain:

(9) $$L_E = \frac{1}{2}(p_E^2 + \beta q_E^2) + H(p_D, q_D)$$

The H term can be dropped from the expression since it only depends on difference variables which cannot be affected by the monetary policy of the European central bank. Furthermore, equation (5) indicates that the average real effective exchange rate of France and Germany q_E can be replaced by $-q_U/2$, where $-q_U$ is the effective real exchange rate of the euro zone. This leads to the following expression, which is formally similar to (7), except for the division by four of the β coefficient.

(10) $$L_E = \frac{1}{2}(p_E^2 + \frac{\beta}{4} q_U^2)$$

Moving to monetary union therefore leads to reducing the weight of the effective exchange rate objective. This reduction does not arise from any particular assumption about the behaviour of the ECB. Rather, it is the mechanical outcome of the reduction in the openness ratio resulting from the creation of the euro zone, which is half as open as for the two constituent countries individually, and whose central bank is not able to target the real FF/DM exchange rate. Note that this result does not mean that the ECB attaches less weight to the exchange rate *of the dollar* than the central banks of France and Germany. On the contrary, we explicitly assume here that its preference for keeping the dollar around its equilibrium value does not change.

In minimising the loss function, we may directly use the real interest rate as the policy instrument when the long run equilibrium does not require domestic price changes (because as inflation has no real effect in the long run, minimising the loss function at period t + 1 simply leads to equating inflation to zero; thus, $p_i^{LT} = p_i$ and $r_i = i_i - [E(p_i^{LT}) - p_i] = i_i$, see Appendix 2). This always applies to floating exchange rate regimes, because any required change in the real exchange rate results from corresponding changes in the nominal exchange rate rather than domestic prices. This also applies to fixed exchange rate equilibria in Europe when shocks are either temporary or symmetric (because the long run real exchange rate remains constant in both cases). The only case in which shocks imply the long-run value of domestic price to change is that of fixed exchange rate regimes (EMU or ERM) in the presence of permanent asymmetric shocks. We shall therefore use the real interest rate as the policy instruments in all cases but this last one.

measuring the welfare effects of alternative exchange rate regimes. It is not consequential if it is used for deriving policy rules, since the first-order condition remains unchanged.

ERM in Europe

What European exchange rate regime should be taken as a benchmark for assessing the effects of EMU is a matter for discussion. There are two reasons for taking a floating rate regime as a benchmark. First, the current wide-band ERM does not differ much from a floating rate regime, *de jure* at least. Second, many observers consider that should the EMU perspective be abandoned, Europe would forsake its attempts at exchange rate stabilisation and move to a floating rate regime. However, Europe has been attempting to stabilise exchange rates at least since 1979, and the wide-band ERM has *de facto* been as a fixed-rate regime since 1993. There are therefore also grounds for comparing exchange rate volatility with Europe in EMU or in the ERM.

As any target zone system, the ERM has complex features, but for this comparison it will be considered here as an asymmetric system in which the *Bundesbank* freely defines its monetary policy while the *Banque de France* maintains a fixed exchange rate with the DM. This kind of representation does not contradict the conclusions of the literature, and it is adopted in most empirical simulations (EC Commission, 1990, or Masson and Symansky, 1992). Furthermore, we disregard the possibility of realignments, we ignore the existence of fluctuation bands, and we assume that the system is perfectly credible and there are no speculative shocks to the FF/DM exchange rate. These rather crude assumptions are more debatable, especially as they prevent from taking into account a possible correlation between DM/dollar and intra-ERM exchange rate. They should be relaxed for an empirical evaluation with model simulations. Finally, we assume that the *Bundesbank* behaves as a Stackelberg leader, i.e. that it takes into account the behaviour of the *Banque de France* when making its monetary policy choices. But the loss function of the *Banque de France* is no longer similar to that of the *Bundesbank*: its only aim is to keep the DM/FF nominal exchange rate stable.

As developed above, the real interest rate can be taken as the policy instrument as long as shocks are either symmetric or temporary. Hence, the monetary policy in the ERM regime can be described as follows:

$$(11)\qquad \begin{cases} Min_{r_G}\ L_G = \dfrac{1}{2}\left(p_G^2 + \beta q_G^2\right) \\ u.c.\ r_F = r_G + \varepsilon_D \end{cases}$$

In the case of permanent, asymmetric shocks, the implications of exchange rate targeting for nominal interest rates must be explicitly taken into account.

2. EXCHANGE RATE STABILITY UNDER VARIOUS EUROPEAN POLICY REGIMES

US behaviour

As the US policy regime does not depend on exchange rate arrangements in Europe, the behaviour of the US economy can be represented by a relation between the real exchange rate and the real interest rate that is invariant with respect to policy changes in

Europe. To establish this relation, we combine the US goods market equilibrium condition (3) with the first order condition from the minimisation of the US loss function:

(12)
$$\frac{dL_U}{dr_U} = p_U \frac{dp_U}{dr_U} + \beta q_U \frac{dq_U}{dr_U} = p_U \left(\frac{\partial\ p_U}{\partial\ r_U} + \frac{\partial\ p_U}{\partial\ q_U} \frac{\partial\ q_U}{\partial\ r_U} \right) + \beta_U q_U \frac{\partial\ q_U}{\partial\ r_U} = 0$$

with $\frac{\partial q_U}{\partial r_U} = -1$, $\frac{\partial p_U}{\partial r_U} = -\frac{\alpha\delta}{1-\alpha}$ and $\frac{\partial p_U}{\partial q_U} = \frac{\alpha\eta\theta}{1-\alpha}$.

The FOC for the US is therefore:

(13)
$$p_U = -\frac{1-\alpha}{\alpha} \frac{\beta_U}{\delta + \eta\theta} q_U$$

Combining (3) and (13) gives a relation between the real exchange rate and the real interest rate, which can be represented in a (r_U , q_U) diagram as an upwardsloping schedule UU:

(UU)
$$q_U = H_U (\delta r_U - \Gamma_U)$$

with $H_U = \dfrac{\alpha}{\dfrac{(1-\alpha)^2}{\alpha} \dfrac{\beta_U}{\delta + \eta\theta} + \alpha\eta\theta}$ and $\Gamma_U = u_U + \alpha\, v_U$

UU is independent of shocks affecting Europe or the dollar exchange rate, but not from domestic US shocks. It represents the reaction of the US central bank, and is upward-sloping because the Fed reacts by raising interest rates to a depreciation of the currency that affects both p and q.

European behaviour under floating exchange rates and EMU

Similar relations can be derived for Europe under alternative exchange regime assumptions. We begin by comparing a free float regime and monetary union. The ERM will be introduced thereafter.

Floating regime Minimising separately the loss functions for France and Germany yields the first-order conditions, which can be expressed in the sum-difference system as:

$$(14)\qquad \begin{cases} p_F\left(\dfrac{dp_E}{dr_F}+\dfrac{dp_D}{dr_F}\right)+\beta q_F\left(\dfrac{dq_E}{dr_F}+\dfrac{dq_D}{dr_F}\right)=0 \\ p_G\left(\dfrac{dp_E}{dr_G}-\dfrac{dp_D}{dr_G}\right)+\beta q_G\left(\dfrac{dq_E}{dr_G}-\dfrac{dq_D}{dr_G}\right)=0 \end{cases}$$

with $\dfrac{dp_E}{dr_G}=\dfrac{dp_E}{dr_F}=\dfrac{1}{2}\dfrac{dp_E}{dr_E}$ and $\dfrac{dp_D}{dr_G}=-\dfrac{dp_D}{dr_F}=-\dfrac{1}{2}\dfrac{dp_D}{dr_D}$, and the same for q. Adding the two condition therefore yields:

$$(15)\qquad p_E\left(\frac{dp_E}{dr_E}+\frac{dp_D}{dr_D}\right)+\beta q_E\left(\frac{dq_E}{dr_E}+\frac{dq_D}{dr_D}\right)=0$$

and a similar condition for variables p_D and q_D.

European aggregate behaviour can thus be represented by a relation between variables p_E and q_E, which is similar to equation (13) for the US and can be calculated using goods market equilibrium conditions (3) and real interest rate parity conditions (6):

$$(16)\qquad p_E=-\Phi^{Float}q_E \text{ , with}$$

$$\Phi^{Float}=\beta\,\frac{\dfrac{dq_E}{dr_E}+\dfrac{dq_D}{dr_D}}{\dfrac{dp_E}{dr_E}+\dfrac{dp_D}{dr_D}}=\frac{\beta}{\dfrac{\alpha}{1-\alpha}(2\eta\theta+\delta)}$$

Relation (16) gives the implicit trade-off between aggregate price and real exchange rate stemming from noncooperative policies conducted independently by French and German authorities.

EMU The equivalent relation under EMU can simply be obtained by minimising the aggregate loss function $L_E=\frac{1}{2}(p_E^2+\beta q_E^2)$. This leads to changing coefficient Φ in equation (16):

$$(17)\qquad p_E=-\Phi^{EMU}q_E \text{ , with}$$

$$\Phi^{EMU} = \beta \frac{\frac{dq_E}{dr_E}}{\frac{dp_D}{dr_E}} = \frac{\beta}{\frac{2\alpha}{1-\alpha}(\eta\theta+\delta)}$$

It is apparent that $\Phi^{EMU} < \Phi^{Float}$, i.e. that the slope of the schedule described by (16) and (17) is lower under EMU than in the free float regime. This means that moving from the floating rate regime to EMU tilts the European trade-off between price and exchange rate stabilisation towards price stabilisation and away from exchange rate stabilisation[10]. The reason for it can be grasped from the expression for Φ in equations (16) and (17): moving from a floating rate regime to monetary union affects the responsiveness to changes in the real interest rate of both exchange rates and prices, i.e. it affects the numerator and the denominator of the expression for Φ. Both terms are in fact lowered, since we have both $\left|\frac{dp_E}{dr_E}\right| = \frac{\alpha}{1-\alpha}(\eta\theta+\delta) < \left|\frac{dp_D}{dr_D}\right| = \frac{\alpha}{1-\alpha}(3\eta\theta+\delta)$ and $\left|\frac{dq_E}{dr_E}\right| = \frac{1}{2} < \left|\frac{dq_D}{dr_D}\right| = \frac{3}{2}$, but the reduction in the numerator is proportionally higher because the move to EMU basically affects a country's ability to modify its real exchange rate through monetary policy changes. Since prices are affected by monetary policy both directly and through the exchange rate channel, this effect exceeds the parallel reduction in the control over domestic prices[11].

Nash equilibrium between Europe and the US

Whatever the European regime, the euro/dollar exchange rate will result from a noncooperative game between Europe and the US. In order to calculate the corresponding Nash equilibrium, we need to transform equation (16) into a real exchange rate-real US interest rate relation. Substituting (16) into the goods market equilibrium condition (3) and using the real interest rate parity condition (6) leads to the following expression:

(EE) $q_U = H_E(\Phi)\left[-\delta r_U + \Delta_E\right]$ where

$$H_E(\Phi) = \frac{1}{\frac{1-\alpha}{2\alpha}\Phi + \eta\theta + \delta}$$

[10] This was already apparent in equation (10). However, the result we have obtained takes into account both changes in the relative weighting of the policy objectives and changes in the transmission channels resulting from the reduced openness of the euro zone.

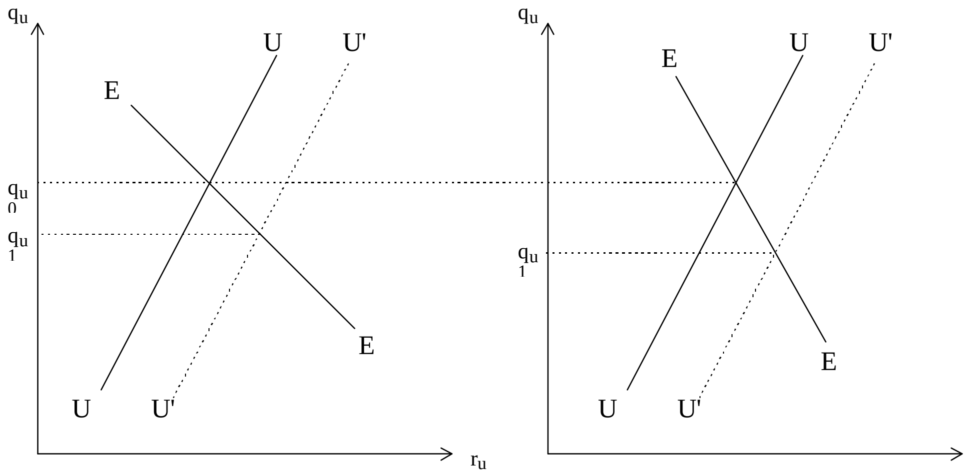
[11] With $\delta = 0$, i.e. no direct domestic demand impact of monetary policy, the two effects would exactly offset.

is a decreasing function of Φ, and Δ_E is a combination of shocks:

$$\Delta_E = \frac{1}{\alpha} u_E + v_E - \delta \varepsilon_E + \delta q_U^{LT}$$

The model can now easily be used to calculate the impact of supply, demand and exchange rate shocks on the euro-dollar exchange rate. Equations (UU) resulting from US behaviour and (EE) resulting from European behaviour can be represented as upward- and downward-sloping schedules UU and EE in a (r_U, q_U) diagram, whose intersection determines the US real interest rate R_U and the real effective exchange rate of the dollar Q_U (Figure 1). Although not conventional, this representation is equivalent to the familiar determination of the Nash non-cooperative equilibrium in a two-countries game.

Figure 1 : Impact of a US shock



What we want to determine is whether the responsiveness to shocks of the real exchange rate of the dollar decreases or increases with EMU. To this end, equations (UU) and (EE) can be written as a system of two equations:

$$(18) \qquad \begin{cases} q_U = H_U(\delta r_U - \Gamma_U) \\ q_U = H_E(\Phi)(-\delta r_U + \Delta_E) \end{cases}$$

where Γ_U represents shocks to the US and Δ_E symmetric shocks to France and Germany (see equations UU and EE).

The solution of the above system is:

(19) $$q_U = \frac{H_E(\Phi)}{1+\frac{H_E(\Phi)}{H_U}}\Delta \quad \text{where } \Delta = \Delta_E - \Gamma_U$$

Δ represents shocks affecting Europe and the US asymmetrically.

It is apparent that $\frac{dq}{dH_E} > 0$, and therefore that $\frac{d}{d\Phi}\frac{dq}{d\Delta} < 0$. Since $\Phi^{EMU} < \Phi^{Float}$, this demonstrates that forming a monetary union in Europe *increases the responsiveness of the real effective exchange rate of the dollar to shocks originating in the US or affecting European countries symmetrically*. Figure 1 depicts it graphically in the case of positive US shocks: the resulting appreciation of the dollar is more pronounced under EMU than under floating exchange rates.

The reason for this result is that under a floating exchange rate regime, France and Germany fail to internalise the externality resulting from their macroeconomic interdependence. Assume for example that Europe is hit by a positive demand shock or an adverse supply shock ($v_A = v_F > 0$ or $u_A = u_F > 0$). In a floating rate regime, both countries raise their interest rate in order to stem the inflationary consequences of the shock, but as they do not internalise the externality, they tend to overestimate the impact of their policy[12]. In the event, the actual REER appreciation turns out to be lower than expected (because both currencies appreciate vis-à-vis the dollar), and inflation remains higher. Failure to internalise the externality results in a weaker tightening of monetary policy than when countries coordinate. Thus, a side effect of the absence of policy coordination under a floating rate regime is that monetary policy tends to overweight the real exchange rate objective and to stabilise the real effective exchange rate of the dollar.

When the two European countries form a monetary union, they internalise their common externality, and the European Central Bank assesses more accurately the impact of its policy. Therefore, it goes for a higher increase in interest rates than under a floating rate regime, and the resulting appreciation vis-à-vis the dollar is more pronounced. By providing automatic coordination in the response to symmetric shocks, monetary union removes a coordination failure and thereby results in increasing the real volatility of the dollar [13].

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[12] This is because $\left|\frac{dp_E}{dr_E}\right| < \left|\frac{dp_D}{dr_D}\right|$.

[13] In the standard, game-theoretical framework, failure to coordinate frequently results in a tighter monetary policy (and thereby a stronger appreciation vis-à-vis third countries) in reaction to positive demand shocks, because each country thinks it can stabilise its economy through appreciating its exchange rate vis-à-vis its partner. This is not the case here because the monetary authorities target both inflation and the real exchange rate. In the absence of coordination, they over-estimate the impact of their monetary policy on the real exchange rate. Thus, the monetary policy under-reacts to shocks. The robustness of our result is further discussed in Section 4.

Equation (19) also indicates that *anti-symmetric* intra-European shocks (u_D, v_D and ε_D) do not impact on the real exchange rate of the dollar, because the effects of the changes in French and German variables automatically offset. This contradicts the naive version of the volatility transfer argument: as long as we compare two symmetric exchange rate regimes in Europe (i.e. float and EMU), suppressing a intra-European adjustment channel can increase the volatility of French and German macroeconomic variable, but does not impact at all on US variables, and in particular does not have any effect on the (nominal or real) effective exchange rate of the US dollar.

An interesting case is that of speculative shocks. A well-known stylised fact is that the FF tends to depreciate against the DM when the DM appreciates against the US$. This asymmetry can be represented in our framework as a relation between the symmetric and anti-symmetric components of speculative shocks. Assume that:

$$(20) \qquad \varepsilon_D = -\rho\varepsilon_G \qquad 0 \le \rho \le 1$$

where r measures the correlation between speculative shocks to the DM/US$ and the FF/DM exchange rates. Equation (20) is equivalent to:

$$(21) \qquad \varepsilon_D = -\zeta\varepsilon_E \qquad \text{with } \zeta = \frac{1}{\frac{2}{\rho} - 1}$$

Such a correlation of shocks does not change the volatility of q_E which does not depend on e_D. But it increases the volatility of both q_F and q_G for a given volatility of q_E. As the asymmetry of shocks should disappear in EMU (q_F and q_G by definition will have the same volatility), this removal of intra-European speculative shocks leads to a lower volatility in the exchange rate of each European country in EMU, while the volatility of the average exchange rate remains unchanged.

More generally, an increase in the real effective volatility of the dollar does not necessarily apply to the DM/$ and FF/$ real exchange rates. Under a floating rate regime, anti-symmetric shocks in Europe impact on the two bilateral dollar exchange rates without affecting the effective exchange rate of the dollar, but this effect vanishes in a monetary union. Depending on the relative size of symmetric versus anti-symmetric shocks in Europe, the bilateral euro/$ real exchange rate could be either more volatile or less volatile than the DM/$ and FF/$ real exchange rates under a floating rates regime. This is a matter which could only be decided upon empirically.

Behaviour under fixed exchange rates: the ERM case

The response of the dollar exchange rate when European monetary policies are coordinated through the operation of an asymmetric fixed exchange rate system can be computed in the same fashion as for EMU or floating exchange rates. The derivation of (11) leads to the following trade-off for Germany:

(22) $$p_G = -\Psi_G^{ERM}\ q_G \qquad \text{with } \Psi_G^{ERM} = \Psi^{EMU}$$

As the *Bundesbank* knows that France will follow a fixed exchange rate policy, it internalises the externality and behaves exactly in the same way as the European central bank as regards the price/exchange rate trade-off. The only difference is that the *Bundesbank* does not react in the same way to shocks occurring in France and in Germany. This is clear from the modified (EE) relation:

(EE') $$q_U = H_E(\Psi_G^{ERM})(-\delta r_U + \Delta_E + \Delta_D)$$

where $H_E(\phi)$ and Δ_E are the same as in (EE), and Δ_D is a combination of 'difference' shocks:

Taking the behaviour of the Federal Reserve (UU) into account, the dollar real exchange rate can be expressed as a function of shocks:

(23) $$q_U = \frac{H_E(\Psi)}{1 + \frac{H_E(\Psi)}{H_U}}\Delta \qquad \text{where } \Delta' = \Delta_E + \Delta_D - \Gamma_U$$

Equation (23) indicates that the reaction of the dollar REER q_U to common shocks (Δ_D=0) is the same as in the EMU regime. This is a well-known result from the theory of policy coordination: a fixed-exchange rate system behaves in the same way as a monetary union as long as shocks are symmetric (Canzoneri and Henderson, 1991).

The difference arises with asymmetric shocks. In a floating exchange rates or an EMU regime, asymmetric shocks do not impact on the (nominal or real) exchange rate of the US dollar because shocks to French and German variables offset. However, they do impact in an ERM regime because the *Bundesbank*, whose loss function only includes German variables, reacts asymmetrically to shocks affecting the German and the French economy. Hence, under an ERM regime, asymmetric shocks in Europe lead to real exchange rate fluctuations between the US and Europe that would vanish in either an EMU or a floating rate regime.

How important can this effect be? It should be expected that as asymmetric shocks tend to be rare among core European countries, they do not account for a large part of the volatility of the dollar-DM exchange rate, and that moving from the ERM to EMU should not reduce it significantly. But here again, the relevance of this effect is a matter for empirical investigation.

The outcome is similar for correlated speculative shocks: in the ERM regime, a speculative shock to the DM/US$ exchange rate, that makes the DM appreciate against both the dollar and the FF, leads to less loosening from the Bundesbank than in EMU. In the ERM regime, the Bundesbank knows that the Banque de France will support part of the stabilization through an increase in its interest rate. This again makes the dollar more volatile against European Currencies in the ERM than in EMU.

Summing up, the REER of the dollar appears more volatile in EMU than in a floating regime, while the comparison with the ERM depends of the share of symmetric, asymmetric and correlated shocks (Table 1)[14].

Table 1: Effect of shocks on the real effective exchange rate of the dollar

Shocks	**Float**	**EMU**	**ERM**
Common shocks			
positive demand shock $v_F = v_G > 0$	+	++	++
negative supply shock $u_F = u_G > 0$	+	++	++
Anti-symmetric shocks			
demand shock $v_G = -v_F > 0$	0	0	+
supply shock $u_G = -u_F > 0$	0	0	+
Correlated speculative shock $e_D = -ze_F$	+	+	++

a plus indicates dollar depreciation

3. Robustness

To what extent are these results robust? Two obvious limitations are (i) the choice of a specific loss function, on which the results might be dependent, and (ii) the way the interactions between countries are described in the model. In this section, we address these limitations. We start by describing more precisely the behaviour of European countries in the presence of symmetric shocks.

The intra-European policy game

In order to clarify the results of the previous section, it may be useful to present them in a traditional game theory framework which explicitly shows how the interest rate of each country reacts to shocks and to the interest rate of other countries.

The reaction functions of France and Germany in a floating exchange rate environment can be derived from (16) and its equivalent in terms of difference variables[15], by replacing prices and real exchange rates by there functions of interest rates and shocks:

[14] It should be reminded that these comparisons assume a continuity both in the preferences of public and private agents, and in the occurrence of the various shocks considered. This exercise should be considered more as a policy benchmark than as a prediction, given the structural shifts that may be triggered by monetary unification.

[15] With $p_F = p_E + p_D$, $p_G = p_E - p_D$, and the same for q_F and q_G.

(24)
$$\begin{cases} r_F = \dfrac{1}{2}\dfrac{A_E}{A_E+\delta}(r_U + r_G) + \dfrac{B_F}{A_E+\delta} \\ r_G = \dfrac{1}{2}\dfrac{A_E}{A_E+\delta}(r_U + r_F) + \dfrac{B_G}{A_E+\delta} \end{cases}$$
, with:

$$A_E = \theta\omega_E + \phi\frac{1-\alpha}{\alpha},$$

$$B_F = A_E\left(\frac{\varepsilon_E - q_U^{LT}}{2} + \frac{3}{2}\varepsilon_D + q_D^{LT}\right) + \frac{\Gamma_F}{\alpha}$$

$$B_G = A_E\left(\frac{\varepsilon_E - q_U^{LT}}{2} - \frac{3}{2}\varepsilon_D - q_D^{LT}\right) + \frac{\Gamma_G}{\alpha}$$

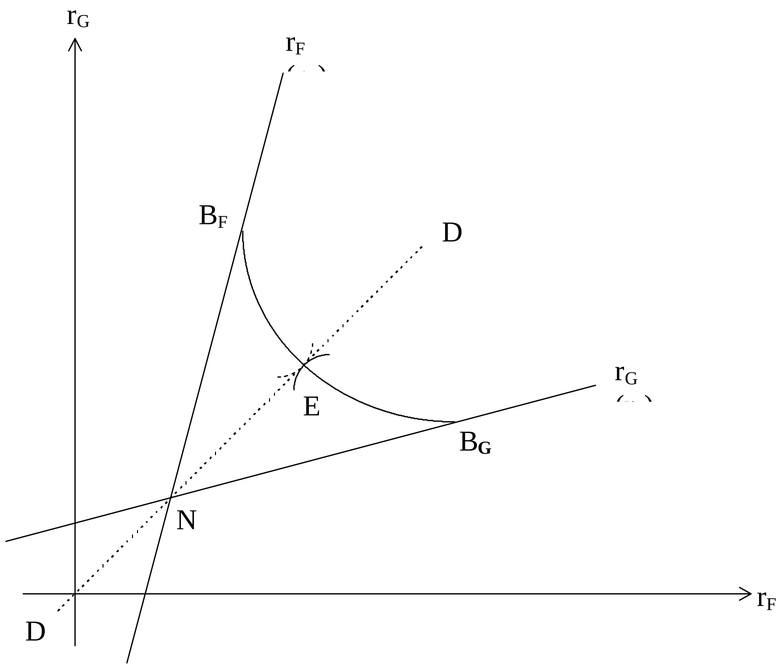
Conversely, under EMU, we have:

(25) $$r_F = r_G = r_E$$

Figure 2 depicts, in the case of a shock affecting the US or the two European countries symmetrically, both the free float Nash equilibrium N and the cooperative EMU equilibrium E, together with the two countries' reaction functions under flexible exchange rates $r_F(r_G)$ and $r_G(r_F)$, and the B_FB_G locus of cooperative equilibria. Note that E is also the equilibrium under fixed exchange rates, with French behaviour being represented by the first diagonal DD.

The figure is similar to usual representations of two-countries policy games, however with two differences. The first one is that, although only the German and the French behaviour are represented, the US reaction function is explicitly taken into account. The second is in contrast to usual results, Figure 2 makes clear that the European countries setting monetary policies independently tend to underreact to symmetric shocks. As developed above, this behaviour results from the inclusion of the real exchange rate among the policy targets. What if we adopt a more usual loss function instead?

Figure 2 : Equilibrium with Fixed FF/DM Exchange Rate



Another loss function

Let us now replace the loss function L = $p^2 + \beta q^2$ by the more conventional function $\Lambda = z^2 + \beta y^2$ (we drop the country subscripts for the sake of simplification). Using exactly the same method as in Section 3, we derive from the first-order condition a relation between z and y:

(26) $z = -\Psi y$

where $\Psi_U = \beta \dfrac{\frac{dy_U}{dr_U}}{\frac{dz_U}{dr_U}}$, $\Psi_E^{EMU} = \beta \dfrac{\frac{dy_E}{dr_E}}{\frac{dz_E}{dr_E}}$, and $\Psi_E^{Float} = \beta \dfrac{\frac{dy_E}{dr_E} + \frac{dy_D}{dr_D}}{\frac{dz_E}{dr_E} + \frac{dz_D}{dr_D}}$

After some algebra, we get:

(27) $$\Psi_E^{FLOAT} = \beta \frac{1}{\frac{\alpha}{1-\alpha} + \frac{2\eta}{2\eta\theta + \delta}}$$ and

$$\Psi_U = \Psi_E^{EMU} = \beta \frac{1}{\frac{\alpha}{1-\alpha} + \frac{\eta}{\eta\theta + \delta}}$$

We therefore have $\Psi_E^{Float} < \Psi_E^{EMU}$.

Forming a monetary union reduces the perceived effectiveness of monetary policy as regards both consumer prices ($\left|\frac{dz_E}{dr_E}\right| < \left|\frac{dz_D}{dr_D}\right|$) and output ($\left|\frac{dy_E}{dr_E}\right| < \left|\frac{dy_D}{dr_D}\right|$), because the lesser openness of the euro zone negatively affects the significance of the exchange rate channel for the transmission of monetary policy impulses. But this reduction effect is stronger for consumer prices. This is because consumer prices are affected by the exchange rate both directly (through its effect on the price of imported goods) and indirectly (through its effect on producer prices), while output (and producer prices) are only affected indirectly. This difference, which does not depend on a particular assumption as regards price elasticities, is crucial to our results[16].

Combining equation (26) with equations (7) and (12) gives:

$$p + \omega q = -\Psi\left(\frac{1-\alpha}{\alpha} p - \frac{1}{\alpha} u\right)$$

Hence,

$$p = \frac{\Psi u - \alpha\omega q}{\alpha + (1-\alpha)\Psi}$$

Substituting into equation (3), we get the following relation between q and r:

(28) $$\omega\left(\theta + \frac{1-\alpha}{\alpha + (1-\alpha)\Psi}\right) q = \delta r - \frac{1}{\alpha + (1-\alpha)\Psi} u - v$$

For the US, equation (28) immediately gives a relation between q_U and r_U that is equivalent to equation (UU) and is also upward-sloping:

[16] With output prices instead of consumer prices, the reduction in the exchange channel in EMU is the same for prices and for output, and EMU no longer modifies the dollar volatility. Nevertheless, the consumer price index seems more representative of the actual monetary policies in Europe (the Maastricht criterion refers to consumer prices).

(UU') $q_U = G_U(\delta r_U - \Omega_U)$

with $$G_U = \frac{1}{\eta\left(\theta + \dfrac{1-\alpha}{\alpha + (1-\alpha)\Psi_U}\right)}$$

$$\text{and } \Omega_U = \frac{1}{\alpha + (1-\alpha)\Psi_U} u_U + v_U$$

Equation (UU') which represents its reaction, means that the US central bank reacts by raising interest rates to a depreciation of the currency that increases both prices and output.

To get the equivalent relation for Europe, we have to substitute the real interest rate parity condition (10) into equation (28). After some tedious calculation we obtain:

(EE '') $q_U = G_E(\Psi_E)(-\delta r_U + \Omega_E)$ where

$$G_E(\Psi_E) = \frac{1}{\delta + \eta\theta + \eta \dfrac{1-\alpha}{\alpha + (1-\alpha)\Psi_E}} \text{ and}$$

$$\Omega_E = \frac{1}{\alpha + (1-\alpha)\Psi_E} u_E + v_E - \delta\varepsilon_E + \delta q_U^{LT}$$

which is formally equivalent to equation (EE), and also downward-sloping. For US shocks as well as demand and speculative European shocks, the resolution is formally similar to that of the (UU, EE) system. Since $G_E(\Psi_E)$ is increasing in Ψ_E and $\Psi_E^{Float} < \Psi_E^{EMU}$, $\left.\dfrac{dq_U}{d\Omega}\right|_{EMU} > \left.\dfrac{dq_U}{d\Omega}\right|_{Float}$, i.e. shocks have a stronger impact on the real effective exchange rate of the dollar when Europe is in a monetary union. This is the same result than with the previous loss function. For European supply shocks, however, things are different because Ω_E depends on Ψ_E. Considering European supply shocks only, we get the following system:

$$\text{(29)} \quad \begin{cases} q_U = G_U \delta r_U \\ q_U = G_E(\Psi_E)(-\delta r_U + B_E(\Psi_E) u_E) \end{cases}$$

with $B_E(\Psi_E) = \dfrac{1}{\alpha + (1-\alpha)\Psi_E}$

the solution of which is:

$$q_U = \frac{G_E(\Psi_E)B_E(\Psi_E)}{1+\delta\,\dfrac{G_E(\Psi_E)}{G_U}}u_E, \tag{30}$$

q_U is decreasing in Ψ_E because $G_E(\Psi_E)B_E(\Psi_E)$ is. We therefore obtain that European supply shocks have a lesser impact on the real exchange rate of the dollar when Europe forms a monetary union, while demand shocks have a larger impact in EMU.

The intuition behind this result comes from the fact that a demand shock hits both output and prices in the same direction, while a supply shock hits output and prices in opposite directions. Take for example an adverse supply shock, that has both an inflationary and a contractionary impact. The policy reaction tends to be muted, as authorities accept to accommodate part of the inflationary consequences of the shock in order not to add to its contractionary effects. As Europe forms a monetary union, with the effect that monetary policy loses more of its perceived effectiveness as an instrument to control consumer prices than for output, the central bank tends to react less aggressively to the inflationary effects of the supply shock. This weaker tightening results in a less pronounced appreciation of the currency.

In the case of a positive demand shock, the monetary authorities increase the interest rates in order to stabilise both output and prices. As consumer prices are more sensitive to exchange rate changes than output, minimisation of the loss function results in a limited increase in interest rates, because authorities keep a balance between the deviations from their two policy targets. In the absence of cooperation, this factor limits the extent of interest rate increases and of the resulting exchange ate appreciation. Moving to EMU results in evening out the differences between output and prices as regards the effects of monetary policy. Hence, the monetary authorities accept a larger exchange rate appreciation in order to stabilise both prices and output.

Summing up, we find that as long as demand shocks prevail, or in the presence of US supply shocks, the previous results remain when social welfare is measured in terms of consumer price inflation and output rather than in terms of producer price inflation and the real exchange rate: monetary union in Europe will tend to increase the real effective volatility of the dollar (Table 2). The significant exception is European supply shocks, which tend to be less consequential for the dollar REER when Europe is in a monetary union regime. Which of the effects will on average dominate could only be decided upon on the basis of a quantitative assessment of the size and the probability of the various shocks.

Table 2: Effect of shocks on the real effective exchange rate of the dollar, with the L loss function

Shocks	**Float**	**EMU**	**ERM**
Common shocks			
positive demand shock $v_F = v_G > 0$	++	+++	+++
negative supply shock $u_F = u_G > 0$	++	+	+
Anti-symmetric shocks			
demand shock $v_G = -v_G > 0$	0	0	+
supply shock $u_F = -u_G > 0$	0	0	+
Correlated speculative shock $\varepsilon_D = -\zeta\varepsilon_E$	+	+	++

a plus indicates dollar depreciation

Alternative spillover effects

Our representation of the three economies is rather standard and fits the usual macro-econometric models used for forecasting. However, a number of assumptions can be disputed.

A first difference with simplified policy coordination models results from the explicit introduction of two spillover effects, through outputs and prices. In the game-theoretical framework, there is frequently only one exchange rate externality, which is removed under EMU. Thus, cooperation unambiguously leads to smaller reactions of monetary policies to shocks, and thus to a smaller exchange rate volatility. In our model, there are two uneven exchange rate externalities which both are internalised under EMU. This is why we obtain a different result.

The most important simplification in our model is the equal treatment of the three economies except for openness. For instance, the price-elasticity of external trade is assumed equal for intra-European trade and for trade with the US. This simplification is removed in Cohen (1997) where the European market is assumed more closely integrated than the world market, which results in a higher price elasticity for intra-European trade. In the EMU regime, European countries internalise both a price externality and an output externality, with the former being relatively higher. Thus, monetary union leads to reducing the volatility of the real exchange rate in the presence of demand shocks and to increasing it in the presence of supply shocks. This is exactly the opposite of our result with the (price, output) loss function.

The reason for this difference is twofold. First, Cohen takes *output* prices and output as arguments of the loss function, which would in our model lead EMU to have neutral effects on exchange rate volatility (because output and output prices move in tandem). Second, Cohen's additional assumption as regards intra-European trade results in making the elimination of intra-European externality more consequential for output than for prices.

Other models hinge on further simplifications. For instance, Martin (1997) assumes that there are only supply shocks, and that all interactions between countries arise from the supply side only. He also assumes that PPP holds, so the real exchange rate is constant by definition. In his model, monetary union removes the supply-side externality between European countries, which has the effect that monetary policy becomes less effective for output stabilisation. The lesser variance in monetary policy translates into a lesser variance in prices and nominal exchange rates. In our model, the impact of monetary union on nominal exchange rate volatility is ambiguous (whereas the impact on inflation is not, as price volatility is lower in EMU), but we consider that real exchange rate volatility is more consequential.

Finally, all analytical models involve highly simplified dynamic interactions. In our model, the second period is the long run, so no further inflation is expected, and the real interest rate equals the nominal one. This simplification is removed in simulations which are based on a dynamic model.

4. QUANTITATIVE EVALUATIONS

The above developments only provide qualitative results. In this section, we provide a rough evaluation of the associated quantitative effects. We first give a numerical evaluation of the multipliers from the theoretical model; next, we present simulations with a simple dynamic model.

The first approach is to start from equation (19), which gives the theoretical short-run impact of shocks on the REER of the dollar when policy preferences are represented by the loss function L, and to evaluate the impact of moving from a floating regime to monetary union in Europe. We take the following values for the parameters:

$\alpha = 0.3$; $\eta = 0.1$; $\theta = 1$; $\delta = 0.2$

For α, the elasticity of output to labour input, this corresponds to usual orders of magnitude for a Cobb-Douglas production function. The value for η, the openness ratio, is close to the empirical magnitudes for the US and Europe. For θ, the output / real exchange elasticity, and δ, the sensitivity of demand to the real interest rate, the values are usual orders of magnitude corresponding to a wide range of macro-econometric models (see e.g. Bryant et al., 1988, Wallis, 1991, or Mitchell et al., 1995).

We can then compute $\left.\frac{dq_U}{dv_E}\right|_{Float}$ *and* $\left.\frac{dq_U}{dv_E}\right|_{EMU}$ as a function of β, the coefficient of the real exchange rate objective in the European loss function[17]. It is apparent that the impact of shocks is larger when Europe is in a monetary union, but the difference does not appear to be large. For example, for $\beta = 0.01$ (which means that a 10% deviation in the real exchange rate has an equal weight than a 1% increase in prices),

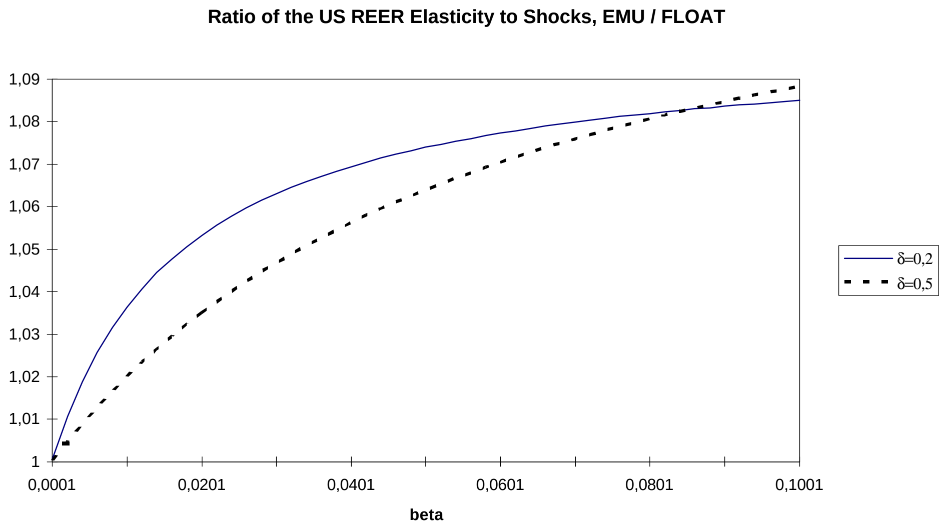
[17] We take $\beta = 0$ for the US, i.e. we assume that the US authorities have no exchange rate objective.

we obtain $\left.\frac{dq_U}{dv_E}\right|_{Float}$ = 1.53 and $\left.\frac{dq_U}{dv_E}\right|_{EMU}$ = 1.60, i.e. moving to EMU would increase the volatility of the real effective exchange rate of the dollar by 3.6%.

Figure 3 indicates that the difference is increasing in β, the weight of the exchange rate objective in the loss function, but remains low for values of β that corresponding to present behaviour in Europe. For example, with β = 0.04 (which means that a 5% REER deviation and a 1% increase in prices have equal impacts on social welfare), moving to EMU would increase the REER volatility of the dollar by 7%. The intuition behind this result is obvious: EMU will only make a difference if European countries attach some weight to real exchange rate stabilisation. If central banks only focus on domestic inflation, there is no reason why moving to a monetary union would significantly impact on exchange rate stability. Obviously, one could argue that moving to monetary union would lead to reducing the value of β because the provision of the Maastricht treaty are conducive to reducing the weight of the exchange rate as a policy objective. This would be an additional reason for an increased REER volatility.

The increase in REER volatility resulting from EMU also depends on the value of δ, the sensitivity of domestic demand to changes in the real interest rate. For δ either infinite or nil, the two regimes would be equivalent. As there is uncertainty as regards the actual value of δ, we plot in Figure 3 the increased volatility of the REER of the dollar as a function of β for two values of δ (0.2 ; 0.5). It illustrates that the difference between the two regimes remains low for realistic values of β and δ.

Figure 3



Numerical evaluations can be misleading because of the highly simplified character of the model. We therefore also provide the results of illustrative simulations with a three-country model which resembles the theoretical model but includes dynamic wage and price equations.

The main characteristics of the model are as follows. Wage inflation depends on past wage inflation, consumer price inflation (i.e. a weighted average of GDP deflator and import price inflation), and excess demand, as with a standard augmented Phillips curve. Producer prices are determined by a mark up on wages. Excess demand reacts negatively to the ex-ante real interest rate (calculated with model-consistent expectations of producer price inflation), and positively to the real effective exchange rate. Identities define the real effective exchange rate as an average of bilateral real exchange rates. Finally, nominal bilateral exchange rates result from uncovered interest rates parity (with the one quarter ahead model-consistent exchange rate expectations). Although highly simplified, this model captures familiar features of empirical macroeconometric models, from which the values of the parameters are taken. The three countries have similar characteristics except for two well known stylised facts. First, we introduce a stronger nominal rigidity in the US, where the average delay for wage inflation adjustments is four quarters instead of two in Europe. Second, the long term elasticity of final demand to the real interest rate is twice higher in Germany than in France and the US.

Policy regimes are represented by interest rate reaction functions for the three countries. We consider two regimes in Europe: a floating exchange rate regime and EMU, and two policy rules represented by linear reaction functions (Table 3).

Table 3: Policy Rules Used in the Simulations

	Consumer price inflation $\hat{z}$ and excess demand y	Producer price inflation $\hat{p}$ and REER q
USA	$i_U = \frac{3}{2}\hat{z}_U + \frac{1}{2}y_U$	$i_U = \frac{3}{2}\hat{p}_U + \frac{1}{20}(q_U)$
Germany *with Float*	$i_G = \frac{5}{4}\hat{z}_G + \frac{1}{2}y_G$	$i_G = \frac{3}{2}\hat{p}_G + \frac{1}{10}(q_G)$
France *with Float*	$i_F = \frac{5}{4}\hat{z}_F + \frac{1}{2}y_F$	$i_F = \frac{3}{2}\hat{p}_F + \frac{1}{10}(q_F)$
ECB *with EMU*	$i_E = \frac{3}{2}\hat{z}_E + \frac{1}{2}y_E$	$i_E = \frac{3}{2}\hat{p}_E + \frac{1}{20}(q_E)$

The policy rules correspond to the loss functions used in the analytical model and involve the same target variables, but the weights attached to the objectives are not formally derived from a loss function. In the first column of Table 3 the monetary policy authority sets its instrument in reaction to deviation from inflation of consumer price and output gap targets, as in the loss function **Λ**[18]. Weights presented are John Taylor's original coefficients, i.e. the real interest rate reacts equally to each arguments of loss function, in the US and in EMU which have the same openness ratio. When Germany and France are in a floating regime, the weight of consumer price inflation is reduced to account for the higher effectiveness of monetary policy on price relative to output consistent with the theoretical model. In column two, we use the target variables of the loss functions **L**, giving to the REER a weight equal to half the openness ratio.

The results of the simulations are presented in Figure 4 (see next page) in the case of a temporary symmetric demand shocks in Europe (a rise of demand by 1% of GDP lasting four quarters). As expected, the response of the US REER is more pronounced with EMU in Europe than with floating exchange rates, and this is true with both policy rules. This also applies to the DM-USD nominal exchange rate. These results hold for a wage shock also, and are robust with respect to reasonable changes in the value of the parameters of the equations[19].

[18] The EC report (1990) did use a weight of 0.4 for the excess demand objective of European countries while the Fed is usualy recognize as weighting equaly prices stability and output in its Taylor rule like specified monetary policy rule.

[19] Some change of the parameters lead to unstable dynamics and divergence. We exclude these. The range of parameters within which we have simulated the dynamic model is available on request to the authors.

Figure 4 : Response of the US REER of the Nominal DM/US $ exchange rate to a symmetric demand shock in Europe (excess demand is increased by 1% during for quarters). Plain lines represent the Float Regime and doted lines is EMU

CONCLUSIONS

It has been repeatedly suggested by European policymakers and politicians that one of the significant benefits of EMU would be its contribution to achieving greater exchange rate stability between the dollar and European currencies. In this paper, we have investigated whether a simple three-countries model could substantiate such a claim.

The short answer is that it does not. On the contrary, there are grounds to consider that in comparison to a floating rate regime in Europe, EMU should increase real exchange rate instability between the Europe and its major trading partners, such as the US or Japan. This result holds for all categories of shocks if one assumes that in addition to their inflation objective, monetary authorities have an explicit real effective exchange rate target. It holds for all but European symmetric supply shocks if it is assumed rather that they have an output target.

There are three caveats that should be kept in mind. First, these results concern the real effective exchange rate of the dollar (or of the euro zone), not the bilateral real exchange rates vis-à-vis the dollar of the individual European countries. As asymmetric shocks affecting individual European countries offset at the level of the euro zone, EMU could simultaneously increase the real instability of the euro zone's dollar exchange rate and reduce those of the member countries' (however, the results are unambiguous for the dollar's REER). The second caveat relates to the baseline situation to which EMU should be compared. We have taken as a baseline a floating rate regime, because we doubt that the ERM would survive in the case EMU would be forsaken. In comparison to an ERM baseline, the effect of a move to EMU will be more ambiguous. Third, the model we have used for deriving these results is highly simplified, as for example France and Germany are considered identical countries and the representation of domestic markets and international linkages is skeletal. This especially applies to the exchange rate, which is derived from an uncovered interest rate parity condition.

What degree of confidence can we place in such a highly simplified model? We tend to believe that the result we come up with has some relevance. Furthermore, the institutional set-up of the Maastricht treaty does not give reasons why it should be opposed, as art. 109 explicitly subordinates the pursuit of exchange rate aims to the overriding objective of price stability.

If this proves to be true, monetary union in Europe would at the same time reduce exchange rate instability within Europe and increase it between Europe and the other major monetary regions. As it is already the case for the US (Bergsten and Henning, 1996), European countries would thus a high degree of real exchange rate stability within Europe, and real exchange rate instability *vis-à-vis* the dollar and the yen. This could not be inconsequential for trade and investment relations within Europe and across the Atlantic.

The empirical significance of this effect should however not be exaggerated. The numerical evaluations provided in this paper, which at this stage of research should be taken as preliminary, suggest that the increase in real exchange rate instability should remain moderate. This is because as European central banks tend to give priority to price stability rather than to attempt at stabilising the real exchange rate, moving to EMU will not fundamentally alter Europe's policy objectives.

APPENDIX 1 : MODEL EQUATIONS

The model is written in log-linear form, except for interest rates, with lower case variables representing deviations from the zero-disturbance equilibrium, and i standing for the country (i=F,G,U).

Goods market equilibrium

Demand in each country *d* increases with the real effective exchange rate *q* and decreases with the real interest rate *r*. It is affected by an exogenous demand shock *v*, which has zero mean. The impact of the real exchange rate is proportional to the degree of openness w, which is 2η for France and Germany, and η for the US.

(I) $d_i = \theta\omega_i q_i - \delta r_i + v_i$ η, θ , δ > 0, and w < 1/2 i = F, G, U

Aggregate supply *y* is derived from a standard Cobb-Douglas production function under the assumption that the capital stock remains fixed both in the short run and in the long run. Labour *n* is therefore the only production factor. Supply is affected by an adverse exogenous supply disturbance *u*, which has also zero mean.

(II) $y_i = (1-\alpha)n_i - u_i$ 0 < α < 1 i = F, G, U

Goods market equilibrium holds in the short run and in the long run, which implies that in the short run output and employment are demand-determined, while they are supply-determined in the long run:

(III) $y_i = d_i$ i = F, G, U

Labour market equilibrium

As firms maximise profits, the marginal productivity of labour is equal to the product wage *w - p* (where *w* is the nominal wage and *p* is the price of domestic production):

(IV) $w_i - p_i = -\alpha n_i - u_i$ i = F, G, U

Labour supply is fixed. In the long run, real wages clear the labour market, but in the short run, nominal wages remain at the level set before shocks are observed. As the expected value of supply and demand shocks is zero, the corresponding conditions are:

(V) $$\begin{array}{l}\text{Long run: } n_i^{LT} = 0 \\ \text{Short run: } w_i = 0\end{array}$$ i = F, G, U

Capital market

The real interest rate *r* is defined as the nominal interest rate *i* less expected inflation:

(VI) $r_i = i_i - \left[E\left(p_i^{LT}\right) - p_i\right]$ i = F, G, U

where $E(x^{LT})$ represents the expected long run value of variable x. We make the usual rational expectations assumption, i.e.:

$$\forall x,\ E\left(x^{LT}\right) = x^{LT}$$

Long run equilibrium values are supposed to be perfectly anticipated by the agents after the shocks have occurred at the beginning of the short run period.

Uncovered interest rate parity holds. If s_F is the nominal US$/FF exchange rate (1 US$ = s_F FF) and s_G the US$/DM exchange rate,

(VII) $$\begin{cases} s_F = E\left(s_F^{LT}\right) + i_U - i_F + \varepsilon_F \\ s_G = E\left(s_G^{LT}\right) + i_U - i_G + \varepsilon_G \end{cases}$$

where ε_F and ε_G are speculative shocks to the exchange rate equation, which can be seen as representing time-varying risk premia. We introduce these shocks because we want to represent the frequently held view that floating exchange rate are responsible for unproductive volatility.

Finally, we define the effective real exchange rate *q*, which depends on trade patterns, and the consumer price index *z*, which depends on the openness ratio:

(VIII)
$$\begin{cases} q_F = \frac{1}{2}(s_F - p_F + p_U) + \frac{1}{2}(s_F - s_G - p_F + p_G) = s_F - p_F + \frac{1}{2}(p_U + p_G - s_G) \\ q_G = \frac{1}{2}(s_G - p_G + p_U) + \frac{1}{2}(s_G - s_F - p_G + p_F) = s_G - p_G + \frac{1}{2}(p_U + p_F - s_F) \\ q_U = \frac{1}{2}(s_F - p_F + p_U) + \frac{1}{2}(-s_G - p_G + p_U) = \frac{s_G + s_F}{2} - p_U + \frac{p_G + p_F}{2} \end{cases}$$

(IX) $z_i = p_i + \omega_i q_i$ i = F, G, U

There are altogether 29 variables, and 26 equations for either the short run or the long run equilibrium. In order to close the model, we have to determine the interest rate, which is done by assuming that monetary policy aims at minimising a macroeconomic loss function L (X), where X represents a set of macroeconomic variables:

(X) Min $L_i(X_i)$, i = F, G, U

List of variables

d_F, d_G, d_U Aggregate demand
y_F, y_G, y_U Aggregate supply
n_F, n_G, n_U Employment
w_F, w_G, w_U Wage rate
p_F, p_G, p_U Producer prices
z_F, z_G, z_U Consumer prices
i_F, i_G, i_U Nominal interest rate
r_F, r_G, r_U Real interest rate
s_F, s_G Nominal dollar exchange rate
q_F, q_G, q_U Real effective exchange rate

Transforming the model

The model can be made much more tractable by exploiting the symmetry between France and Germany through the usual Aoki transformation. For each variable x, we therefore define the 'sum' European variable as:

$$x_E = \frac{x_F + x_G}{2}$$

and the 'difference' variable as:

$$x_D = \frac{x_F - x_G}{2}$$

The model can thus be rewritten with variables x_E and x_D replacing x_F and x_A. Obviously, $x_F = x_E + x_D$ and $x_G = x_E - x_D$, which means that country variables can easily be calculated from aggregate sum and difference variables. This transformation allows to re-write equations (I) to (VI) and equation (IX) with i=E,D,U. Only equations (VII) and (VIII) are modified:

(VII') $$\begin{cases} s_E = E\left(s_E^{LT}\right) + i_U - i_E + \varepsilon_E \\ s_D = E\left(s_D^{LT}\right) - i_D + \varepsilon_D \end{cases}$$

(VIII')
$$\begin{cases} q_E = \frac{1}{2}\left(s_E + p_U - p_E\right) \\ q_D = \frac{3}{2}\left(s_D - p_D\right) \\ q_U = -s_E - P_U + p_E = -2q_E \end{cases}$$

q_E is the average of the effective real exchange rates of France and Germany, which differs from the effective real exchange rate of Europe $-q_u$.

APPENDIX 2 : LONG TERM SOLUTION OF THE MODEL

Goods market equilibrium conditions in the long run are:

$$\text{(XI)} \qquad \begin{cases} y_E^{LT} = -u_E^{LT} = -\eta\theta\, q_U^{LT} - \delta \bar{r}_E^{LT} + v_E^{LT} \\ y_D^{LT} = -u_D^{LT} = 2\eta\theta q_D^{LT} - \delta r_D^{LT} + v_D^{LT} \\ y_U^{LT} = -u_U^{LT} = \eta\ \theta\ q_U^{LT} - \delta\ r_U^{LT} + v_U^{LT} \end{cases}$$

where u^{LT}, v^{LT} represent the long-run values of the shocks (we do not necessarily assume that supply and demand shocks are temporary). Real exchange rate stationarity implies that there is only one world real interest rate, which ensures goods market equilibrium:

$$\text{(XII)} \qquad y_E^{LT} + y_U^{LT} = -\left(u_E^{LT} + u_U^{LT}\right) = -2\delta\, r^{LT} + \left(v_E^{LT} + v_U^{LT}\right)$$

Equations (XI) and (XII) give the long run real interest rate and the long run real effective exchange rate of the dollar:

$$\text{(XIII)} \qquad r^{LT} = \frac{1}{2\eta\theta}\left(v_E + v_U + u_E + u_U\right)^{LT}$$

$$\text{(XIV)} \qquad q_U^{LT} = \frac{1}{2\eta\theta}\left[\left(u_E + v_E\right) - \left(u_U - v_U\right)\right]^{LT}$$

Shocks affecting the US and Europe symmetrically impact on the world real interest rate, while asymmetric shocks impact on the real exchange rate of the dollar. Finally, the FF/DM real exchange rate depends on asymmetric shocks in Europe:

$$\text{(XV)} \qquad q_D^{LT} = -\frac{1}{2\eta\theta}\left(u_D + v_D\right)^{LT}$$

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